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COMMUNIST CHINA'S RESEARCH ON LONG-RANGE WEATHER FORECASTING DURING THE PAST DECADE

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Since the establishment of New China in 1949, Socialist construction projects have made rapid progress and industrial and agricultural enterprises have embarked upon unprecedented production under the correct leadership of the Chinese Communist Party. The demand for weather forecasting by the various productive agencies has become increasingly more urgent, and apart from short-range forecasting, the call for medium-and long-range forecasting has graduallly increased.

For the past decade, there has been rapid progress in meteorology in China, and great achievements have been made--whether in the establishment of meteorological stations, or in the training of cadres, or in research.

At the same time, China's research on long-range weather forecasting for the past decade is no exception to this rule. In 1958 medium-and long-range weather forecasting was declared by the Central Meteorological Bureau to be one of the three cardinal meteorological "marshals" (atmospheric control, agricultural meteorology and medium-and long-range forecasting), to which full notice was given by the meteorological stations of China.

On the basis of this leap forward were evolved many methods for medium-and long-range weather forecasting tests.

The effect of such forecasting on agriculture, fishery, industry, etc. was definitely reassuring. An introduction to the development of medium-and long-range weather forecasting and research during the past decade in China was already given in the weather section of "A Summary of Ten Years of Scientific Accomplishments." We are now concerned with an introduction and evaluation of some highlights of long-range weather forecasting and accomplishments.

During the twenty or thirty years prior to the founding of New China, research on long-range weather forecasting was conducted on the scientific basis then existent, and some outstanding achievements (1-4) were known to have dealt principally with the historical aspect of China's climatic changes, and with temperature and precipitation in relation to world's climate.

Apart from multiform research on long-range weather forecasting during the past decade, New China has witnessed the establishment of routine long-range weather forecasting work.

In the early part of 1959 the Central Institute of Meteorology already had made a one-year forecast on monthly temperature, and rainfall distribution by area; six-month forecast on weekly temperature, and rainfall distribution by area; and a three-month forecast on air cycle flucatuations, temperature, and distribution of precipitation by area (5).

Research on long-range weather forecasting published in 1950 was calculated principally to analyze flood and drought years in the past. Based on a five-day average surface atmospheric pressure in the Northern Hemisphere, an analysis was made of the discrepancy in air circulation and of air current patterns (6) during the flood and drought years.

In the summer of 1931 when the Yangtze Valley in China was the scene of torrential water, the air-flow in East Asia was found to be of the cyclonic type, and precipitation was especially abundant due to India's cyclonic influence.

In the summer of 1934 when the Yangtze Valley in China was gripped by a great drought, the air-flow had an anti-

cyclonic pattern caused by the anticyclone in the Pacific Ocean. Again, the sea water temperature in the Pacific and in the vicinity of Japan may have some bearing on flood and drought years in China [7].

The distribution of flood and drought areas in China may be examined according to three standard types of sea water temperature: the north-cold and south-warm model, the cold-water model, and the warm-water model. The north-cold and south-warm model mainly results in precipitation in China and Japan, but in ascertaining the precipitation belt in China, account should be taken of the rise and fall in the barometric maxima of "O-ho-ts'u-k'o" and Ogasawara.

As a rule, the precipitation belt of the cold-water type is located in a zone north of the Yangtze Valley extending from North China through Northeast China to Korea, while the Yangtze Valley itself falls within the drought zone.

The barometric maximum of "O-ho-tz'u-k'o" does not figure prominently in the case of the warm-water model, since the distribution of temperature and precipitation in China varies from year to year and is not so simple as the two sea-water models mentioned above.

By means of this reasearch we have come to understand adequately the repercussion of water temperature on air circulation characteristics in China during flood and drought years.

The announced task for 1951 was to analyze such meteorological factors as temperature, precipitation, etc. in the light of their historical changes during the past several decades, with emphasis on their secular, homogeneous and cyclical trends as well as their maximum and minimum possibilities and points of deflection, so that a method might be evolved of monthly forecasting [8] a year in advance.

Basically, this task was based on the concept that any factor that had caused changes to occur in the atmosphere either from without or from within, historically speaking, would be a factor influencing meteorology.

While it is impossible for us to identify and determine at present the extent to which this influence may be attributed to different individual factors, the comprehensive

influence from such factors was completely reflected in the historical changes of meteorological factors themselves. Therefore, if we were able to discover a law governing the historical changes of meteorological factors, we would have direct control over weather forecasting.

While this task would help open up a concrete, practical, simple and domestic path for making long-range weather forecasts, the essential phase of changing physical properties under long-range weather conditions was neglected.

In the final analysis, it would only serve as an auxiliary tool for long-range weather forecasting to be substantiated by revised reference materials.

Besides, it is worthy of note that as a result of this effort some characteristics of atmospheric circulation and climatic changes during the past several decades were pointed out. For example, the average annual circulation intensity in the westerlies belt of the Northern Hemisphere in the 1910-1930 period was comparatively strong, and it was rather weak before and after.

At the same time, the average annual westerlies circulation index for the 1900-1940 period showed a high in a five-year cycle and a low in a four-year cycle. Since 1920 typhoon outbreaks in the West Pacific--numerically speaking-- had clearly indicated a five-year cycle.

Again, since 1873, winter temperature in Shanghai had decidedly shown a two-year cycle, while the rate of precipitation in July for the 1906-1936 period at Mukden had definitely indicated a three-year cycle.

A research report[9] on the method of extrapolating long-range weather forecasting by applying local meteorological elements of the month before and after was issued in 1952. By examining the relationship existing between the amount of precipitation in the summer months of the 1906-1936 period at Mukden and the various local meteorological factors of the months before, the following qualitative rules were arrived at:

(1) When the temperature of the preceding month at Mukden was marked by higher atmospheric pressure and low humidity,

rainfall in the succeeding month was likely to be more abundant; when there was lower temperature and atmospheric pressure and higher humidity in the preceding month, precipitation in the succeeding month was likely to be less plentiful; (2) when temperature, atmospheric pressure and humidity in the preceding month was simultaneously higher or lower, the amount of precipitation in the succeeding month was likely to be comparatively normal; (3) when there was high humidity and low wind velocity regardless of temperature and atmospheric pressure being high or low in the preceding month, the amount of rainfall-- especially in June and August-- in the succeeding month was likely to be abnormal; (4) when high humidity and low wind velocity in the preceding month was followed by low temperature and atmospheric pressure, precipitation in the succeeding month would be less but it would increase if high humidity and low wind velocity were accompanied by high temperature and atmospheric pressure; (5) when there was high temperature, low atmospheric pressure and high humidity in the preceding month or low temperature, high atmospheric pressure and high humidity, precipitation in the succeeding month would be normal.

By observing the development of stability in atmospheric pressure in the subtropical belt and by noting changes in westerlies circulation intensity, a definite interpretation for the rules mentioned here could be derived.

Although, in conducting this task, local historical source materials before and after were analyzed to explain the development of long-range weather phenomena, an analysis of single-station data was still necessary.

Subsequently, the single-station method for long-range weather forecasting was developed [10-12] through the application of meteorological factors before and after, and an understanding of their relationship. Unfortunately no adequate attention had been accorded to the proper understanding of long-range weather processes.

Although some supplementary rules for weather forecasting work were formulated by first analyzing single-station annual materials, yet laws governing changes in long-range weather processes and their physical phenomena remained to be clarified. A comprehensive report [13-14] on how to profit from the Soviet Union's advanced experience in long-

range weather forecasting was issued after 1953, and on the basis of Mul'tanovskiy's school of thought, a study of the characteristics of long-range weather processes in East Asia was made.

In this connection, two such reports (15-16) were published in 1956 revealing the cause for an abrupt drop in temperature in China due to the cool-type barometric pressure and pointing out laws responsible for the development of definite phase series according to the Polar activity of the earth's axis.

Generally speaking, the "K'o-la" Sea [Kola Bay?] process was composed of five phases(15): the first phase was marked by a powerful high pressure ridge in the air-mass of West Europe, pointing to the Black Sea trough in the east and a low trough in East Asia at a phase average of four days; the second phase was characterized by the expansion and then contraction of ahigh pressure ridge in the air-mass in Central Europe with a trough moving from the "O-pi" [Ob?] River to "Yen-hai" at a phase average of 10 days;the third phase was defined by barometric pressure (or ridge) in the "Hu-la-erh" region, expanding northward with all of East Asia dipping into a giant trough at a phase average of nine days; the fourth phase was marked by a high pressure ridge in the air-mass over the "Hu-la-erh" region, developing fully in a northeasterly direction with a Polar process in the surface area at a phase average of four days; and the fifth phase was characterized by a large mobile trough from Central Siberia moving eastward and a surface cool-type high pressure penetrating into China at a phase average of five days.

It would take 30 days to move from the first phase warning to the development in China of an abrupt fall in temperature. In the event that the first three phases had been completed, a sudden drop in temperature in China could be predicted in 10 days with some degree of certainty.

At the same time, it was verified that the rhythmic effect of the Earth's processes in the Polor region on atmospheric conditions in East Asia had also existed in an objective sense(16). Three 90± 2-day rhythmic laws were evolved; first, when a homogeneous process occurred three months before the initial process, there was an 89 percent probability that a similar process would not come to pass

three months after the initial process; secondly, when a dissimilar process took place three months before the initial process, there was a 66 percent probability that a similar process would occur three months after the initial process; and thirdly, when a reciprocal process occurred three months before the initial process, there was an 80 percent probability that there would be a similar process after the initial process. The rhythmic activity of the Earth's processes in the Polar region of East Asia, based as it was on later research, was not at all satisfactory (17).

Research reports (18) on the characteristics of large-scale monthly mean temperature in China, as measured positively or negatively from an anomalous region were published in 1956. On the basis of a 20-year source materials, it was revealed that the over-all temperature for negatively anomalous months (cold months) was comparatively concentrated over a certain period, in which the possibility of an over-all temperature of positively anomalous months (warm months) was less likely.

The possibility of a cold month occurring twice with a month's interval was much greater, and in a period of six months before or after the warm months there was a greater likelihoo that warm months rather than cold months would come to pass.

Laws on the rhythmic behavior of cold and warm months as reflected in long-range weather processes were established. For example, (1) during the six months after the occurrence of a cold month twice with a month's interval, there was less possibility of a warm month occurring in the second month than of a cold month reappearing in the third month; (2) when a warm month appeared in the second month before the cold month, the probability of a cold month appearing after the second month was very much greater; (3) there was a possibility of a cold month reappearing in the second month after the appearance of a cold month twice with a two-month interval; (4) there was less probability of a cold month appearing in the six month period following the appearance of a warm month twice with a month's interval, and the possibility of a cold month appearing in the third or fifth month was almost nil; and (5) there was little likelihood of a warm month reappearing in the six-month period after the occurrence of a warm month twice with a two month interval, and it was most improbable that a warm month would appear in the fourth or sixth month.

This type [of study] involves regional distribution of monthly mean temperatures in their before and after relationship, and contributes significantly to an understanding of China's climatic characteristics in actual long-range weather forecasting. Nevertheless, to disregard the causes of atmospheric circulation in solving this type of problem cannot improve our basic knowledge of long-range weather phases.

An important research report(19) dealing with changes in long-range weather processes in East Asia was published in 1956. This work concentrated on the features of summer weather in China in reference to seasonal delineation. By analyzing changes in westerlies intensity at various longitudinal cross sections, useful, transitional seasonal indexes were obtained.

Dissipation of strong westerlies at lower latitudes crossing longitude 65° E. at 500mb was regarded as an indicator of the commencement of the rainy season, while expenditure of upper strong westerlies south of latitude 40°N. crossing longitude 140°E. at 500mb symbolized the advent of summer.

Related to these weather process characteristics were the disappearance of air troughs in East Asia and the northerly shift of a subtropical high pressure belt in the Pacific toward latitude 30-40°. With the beginning of average summer temperature on 13 July the inclement weather terminated. Resumption of strong westerlies at latitude 30-40° crossing longitude 140° E. at 500mb marked the end of summer and the beginning of autumn.

At the same time, a huge air trough in East Asia was reinstated, and a surface, cool-type, high pressure area moved from east of "Hsin-ti-tao" in a southeasterly direction toward North China. An average for this period was reached on 5 September, which accounted for the fact that the average length of summer in East Asia was 55 days.

Simultaneously, westerlies of 500mb strength appeared irregularly at various longitudes, generally losing their force earlier in the west than in the east. Unlike those that were first established in the upper jet-stream in winter, these westerlies appeared late.

The high pressure ridge over Japan in the Pacific was a distinct mark for the weather process in summer, and differences in summer circulation for various years were represented by the changes in the east-west position of this pressure ridge. Again, the average depth of the low trough in the vicinity of Lake Baikal constituted an important part of the changes in air-flow for various years. The broadest swing from troughs to ridges during various years was observed near the Ural Mountains.

The work of synchronizing changes in atmospheric circulation with surface weather processes in delineating seasonal changes with simple indexes contributed significantly to the research on long-range weather processes in East Asia.

With the gradual substantiation of atmospheric data in China, the gradual completion of weather charts, and the increase of historical weather maps by years, the conditions for research on circulation processes and weather patterns and for conducting long-range weather forecasting were good after 1957.

In this connection, an over-all comprehensive method for weather forecasting was evolved. For example, by studying long-range weather process characteristics during six summer months in terms of seasonal changes in atmospheric circulation, a practical method for forecasting the amount of precipitation during the rainy season in the middle-upper reaches of the Yangtze River from 10 days to 6 months was devised[20-21].

It was possible to study in great detail such features of atmospheric circulation as wave indexes for westerlies, south-north exchange, the field situation of key areas (Urals, "O-ho-tz'u-k'o" Sea, India and the Pacific Ocean) and rules governing changes of phenomena (longitudinal extent of the jet stream, convergence area, south and north wind velocity at specified latitudes, etc.).

The exact meaning of "mei-yu" (rainy season) and its chronological commencement dates, as well as air circulation characteristics prior to its commencement could be ascertained and pointed out. Definite features derived from seasonal changes in the intensity of the westerlies at longitude 140° E. 82 days before the beginning of the

"mei-yu" period were used as an average to forecast its commencement in the Yangtze River.

Furthermore, the distribution of a ten-day precipitation grand total in the Yangtze Valley could be classified to regulate the development of various rain models, and their relationship to changes in the atmospheric circulation characteristics and key area field situation could be established. These relationships could be explained with reasonable certainty from the standpoint of synoptic meteorology.

As a result of this research, not only was a comparatively concrete plan for weather forecasting evolved but also the substance of long-range weather processes in East Asia, and the mutual relationship and restraint between long, medium-and short-range weather processes were given close attention. This reasearch work is now being continued.

By classifying weather cycles in East Asia for the past decade, cyclical rhythms and their correlation before and after could be traced for the formulation of a plan for seasonal long-range weather forecasting[22]. Recently, by breaking down weather models, weather cycles and precipitation models at low latitudes, and by establishing further correlation and coordination between various cyclical processes and precipitation models, a long-range weather forecasting plan based on the sequence of precipitation cycle models and the development of atmospheric circulation processes during the rainy season in China from May to September was worked out[23]. This study is also being continued.

Again, based on recent long-range weather forecasting studies of large-scale air-flow by the Soviet Institute of Polar Research, a long-range weather forecasting plan correlating the development of seasonal atmospheric circulation in the Northern Hemisphere to the distribution of temperature and precipitation by month in China had been worked out[24-25].

Preliminary success was also attained in weather forecasting tests on average monthly stratospheric conditions in East Asia, on the basis of Na-mei-ai-ssu's publication on "remote" dynamics in 1953[26]. By analyzing monthly

precipitation grand total and annual changes in the 500mb average monthly level, the characteristics of biennial change were discovered and a plan for forecasting the monthly average 500mb position and the distribution of monthly precipitation, as measured by anomalies, could be ascertained a year in advance. These studies are being continued.

Recently, research on weather forecasting has been undertaken by meteorological departments and educational units throughout the country. As their results are yet to be announced, they cannot be dealt with for the time being. Work has begun on long-range weather forecasting in China by hydrodynamic and thermodynamic methods, and definite achievements have been made. Details are given in an article on "Quantitative and Qualitative Studies on Weather Forecasting During the Past Decade."

In short, from this brief introduction it may be gauged that during the past decade a distinct achievement in long-range weather forecasting has undoubtedly been made. Practical methods for weather forecasting have been devised. regarding the analysis of weather source materials, atmospheric circulation processes, classification of weather models, and average monthly air pressure. Apart from actual weather forecasting work undertaken by the units concerned, there is a substantial increase in the understanding of the long-range weather process in East Asia and weather characteristics in China, Of course, much ground remains to be covered before the effect of long-range weather reporting can actually be evaluated. Only Only through the collective effort of the researchers attacking the problem from many directions can this problem be solved.

As long as physical causes for the development and formation of atmospheric circulation remain unclarified, and as long as the physical quality of the long-range weather process remains to be explained, the effectiveness of weather forecasting will be restricted in terms of quality.

While we should, on the one hand, do our utmost in improving the method of weather forecasting from now on, we should, on the other hand, strengthen our research on the theory of atmospheric circulation. When theory is coupled with fact, the accuracy of weather forecasting is fundamentally improved.

It is our strong belief that under the correct leadership of the Party and the Fatherland's brilliant guidance during the great leap forward in industry and agriculture, new achievements in research on long-range weather forecasting will be attained without interruption.

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